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# **Voluntary Export Restraints and Resource Allocation in Exporting Countries**

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By reducing the marginal revenue of the factors of production, a voluntary export restraint (VER) causes an exporting country's industry to contract. Efficiency losses depend on whether sales can be diverted from restricted to unrestricted markets. A VER is likely to produce a welfare loss if demand is relatively elastic and supply is not.

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Most literature on voluntary export restraints (VERs) analyzes the welfare costs of VERs to consumers in the importing country. De Melo and Winters propose a method for measuring the effects of a VER on the productivity of factors employed in the exporting industry.

Their model measures how a VER affects both revenues and efficiency (which may be affected by contraction of output) in an exporting industry. They used the model to estimate the effects of the U.S. Orderly Marketing Agreement (OMA) on Korean producers of leather footwear in 1977-81.

Their econometric estimates indicate a limited ability to redirect sales to unrestricted

markets and a sharp fall in the marginal revenue product of factors employed in the Korean leather footwear industry during the period the OMA was in effect.

They found that the marginal revenue product of factors employed in leather footwear declined as much as 9 percent because of the OMA. This estimate was corroborated by time series on output, employment, and wages in the Korean footwear sector.

Based on illustrative counterfactual simulations, de Melo and Winters show that a VER is likely to produce a welfare loss if demand is relatively elastic and supply is not.

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in Exporting Countries\*

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## 1. Introduction

The bulk of empirical work on voluntary export restraints (VERs) has focused on establishing the welfare costs of these arrangements to the consumer in importing countries. Examples include: the quality-adjusted welfare cost estimates to consumers of VERs on autos (Feenstra (1984), and Dinopoulos and Kreinin (1988); the argument that for products where differentiation and start-up costs are low (e.g. footwear, textiles), VERs are ineffective and hence that protection is porous (Baldwin (1982), Bhagwati (1986)); and the use of calibrated simulations to show that terms of trade effects are likely to reduce substantially the costs (gains) to importing (exporting) countries (Tarr (1987), Trela and Whalley (1988)). None of these studies, however -- even those which look into the implications of VERs for exporters -- estimates directly the resource allocation implications of VERs for exporters. The purpose of this paper is to fill that gap.

More precisely, the contribution of this paper is to propose a method to measure the effects of a VER on the productivity of factors employed in the exporting industry. In section 2, an intuitive discussion establishes that, under fairly general conditions, a VER will lead the industry to contract. In section 3, we estimate econometrically the effects of the U.S. Orderly Marketing Agreement (OMA) for non-rubber footwear imports on the marginal revenue product of factors employed in the Korean leather footwear industry during 1977-81. We estimate that the fall in the marginal revenue product of factors in footwear was as much as 9% because of the OMA. We then use in section 4 our econometric estimate of the ease with which sales were diverted from restricted to unrestricted markets to give illustrative calibrated estimates of the likely welfare

effects of the OMA on Korean leather footwear exporters. Conclusions follow in section 5.

## 2. Resource Allocation Implications of a VER

In this section, we discuss the revenue and the resource allocation implications for an exporting country entering a VER. To simplify the exposition, we assume that all output (produced by identical firms in perfect competition in all product and factor markets) is sold in one of two foreign markets, and that a VER restricts exports to one of these markets while those to the second market remain unrestricted. (In the empirical application, output is sold to three markets.) In addition, we assume that individual exporting firms are price-takers in each export market, though the industry as a whole faces downward sloping demand curves in each market. The purpose of the analysis is to establish under fairly representative conditions that a VER will reduce the marginal revenue product of factor inputs in the affected industry, and hence reduce the size of the industry.

For expositional purposes, we discuss the effects of the VER in two steps. First, we discuss the effects of the VER on the assumption that industry size is fixed and that there are costs to diverting sales from the restricted towards the unrestricted market. With the assumption that the size of the industry remains unchanged it is easy to analyze intuitively the revenue and distortionary implications of the VER. In a second step, we show that a VER will likely lead the industry to contract. Besides being expositionally convenient, this two-step analysis corresponds to the two-stage assumption about firm decisions that has to be adopted in the econometric work of section 3. However, as we show in appendix B, the weak

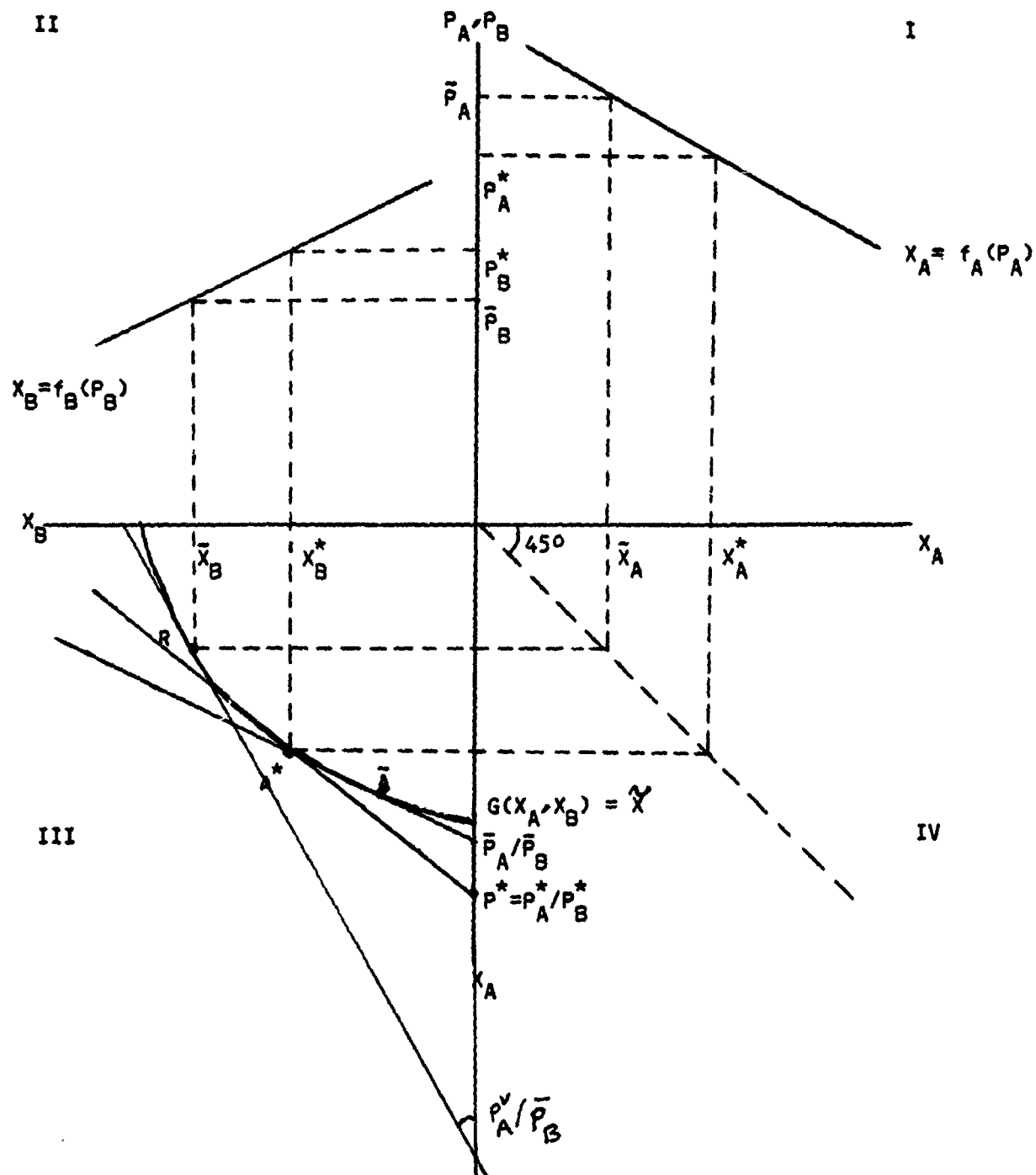
separability between input decisions and sales decisions that it implies is not necessary for the results that are established here.

The assumption that there are increasing marginal costs to diverting sales from the restricted towards the unrestricted market may be interpreted as indicating the short-run effects of a VER. In the short-run, with the quantities of factors employed in the industry being fixed, different factor intensities will result in increasing marginal costs to altering the product mix. Alternatively one can view the two products as differentiated. 1/

The above assumptions allow us to represent our model diagrammatically. In figure 1, foreign export demands in the restricted (A) and unrestricted (B) markets are represented in quadrants I and II, respectively, while quadrant III depicts the substitution possibilities facing the industry as it reallocates production between sales ~~for market A~~ and those for market B. It is obtained by the aggregation ~~of~~ the substitution possibilities facing each representative exporter. The bowed-out shape of the "export transformation" curve,  $G(X_A, X_B) = \tilde{X}$ , reflects the assumption of increasing costs to product mix shifts. Assuming that one can write an aggregate footwear production,  $\tilde{X}$ , successive increments in sales to market B impose increasing resource costs in terms of larger and larger decreases in export sales to market A. Quadrant IV is the 45° line which translates export sales to A from quadrant III to quadrant I.

The unrestricted allocation,  $A^*$ , is represented by the price-quantity pairs  $(P_A^*, X_A^*)$  and  $(P_B^*, X_B^*)$ , where superscript asterisks are used to denote the unrestricted equilibrium. 2/ The slope of the export transformation curve is given by

Figure 1



$$MRT_{A,B} = \frac{dX_A}{dX_B} = - \frac{G_B}{G_A} < 0$$

where  $G_i = \partial G / \partial X_i > 0$ ,  $i = A, B$ , indicates positive marginal costs, and the bowed out transformation curve reflects the fact that marginal costs increase with output. 3/

The equilibrium for the competitive industry requires that

$$(1) \quad \frac{G_A^*}{G_B^*} = \frac{P_A^*}{P_B^*}$$

and  $P_i = \theta^* G_i$  where  $\theta^*$  is the marginal cost of producing a unit of  $\tilde{X}$ . In figure 1, the equilibrium condition (1) is represented by the tangency of the export transformation curve and the price line  $P^*$ , at the unrestricted equilibrium,  $A^*$ .

Now impose a VER which restricts exports to A to the level  $\bar{X}_A$ . The restricted allocation is represented by the new price-quantity pairs  $(\bar{P}_A, \bar{X}_A)$  and  $(\bar{P}_B, \bar{X}_B)$  where superscript bars indicate the restricted equilibrium. Because we have assumed that the industry as a whole does not behave like a discriminating monopolist (due to the assumption of an atomistic industry), it is possible that the VER will raise revenues. Denoting by  $\epsilon_A, \epsilon_B < 0$  the elasticities of demand in the restricted and unrestricted markets respectively, a departure from the free trade equilibrium will raise revenues if marginal sales revenue is higher in B than in A, i.e. if  $P_B(1 - 1/\epsilon_B) > P_A(1 - 1/\epsilon_A)$ . Thus if the elasticity of demand is much greater in the unrestricted than in the restricted market, a



VER may push sales allocation towards that which would be selected by a discriminating monopolist. 4/

Consider next the distortionary implications of the VER. Because we have assumed at this stage that firms maximize profits for a given level of  $\tilde{X}$ , the new allocation must lie on the same export transformation curve, and, given the exogenous value of  $\bar{X}_A$ , the chosen point will be R. Thus, given the overall level of input, the VER determines sales to the unrestricted market as well as to the restricted market. At the new equilibrium the equality of relative prices to the marginal rate of transformation no longer holds. The relative price of A has been forced up by the constraint on sales, but the marginal rate of transformation ( $MRT_{A,B}$ ) has fallen as the relative output of A has fallen. Hence

$$\left( \bar{P}_A / \bar{P}_B > P_A^* / P_B^* \right) \quad \text{whereas} \quad \left( \frac{\bar{G}_A}{\bar{G}_B} < \frac{G_A^*}{G_B^*} \right).$$

This violation entails a well-understood distortion cost, regardless of whether total sales revenues have increased after the imposition of the VER. For producers to choose point R voluntarily, they would have to be confronted by the relative price line  $(P_A^V / \bar{P}_B)$  which equals the marginal rate of transformation at R.

We now turn to the second step of the discussion and show that the VER will create an incentive for the industry to contract. With production and allocation decisions separable, input mixes (which depend on factor prices) are independent of output mixes (which depend on output prices); hence given exogenous factor prices we can construct a composite factor, 2,

with wage  $W$ . This allows us to characterize production in terms of the aggregate output index as  $\tilde{X} = \tilde{X}(Z)$ , and assuming constant returns to scale, we can select units such that  $\tilde{X} \equiv Z$ .

In an unrestricted equilibrium, sales are allocated between markets in such a way that the marginal revenue product of a factor devoted to producing goods for market A equals that of the factor if it were used to produce for market B. Thus we may write

$$(2) \quad \frac{dR_A}{dZ} = \frac{dR_B}{dZ} = \frac{dR}{dZ} = W$$

where  $R_A$  is the revenue derived in market A, etc. and where, in our earlier notation,

$$\frac{dR_i}{dZ} = \frac{P_i^*}{G_i^*} = \theta^*$$

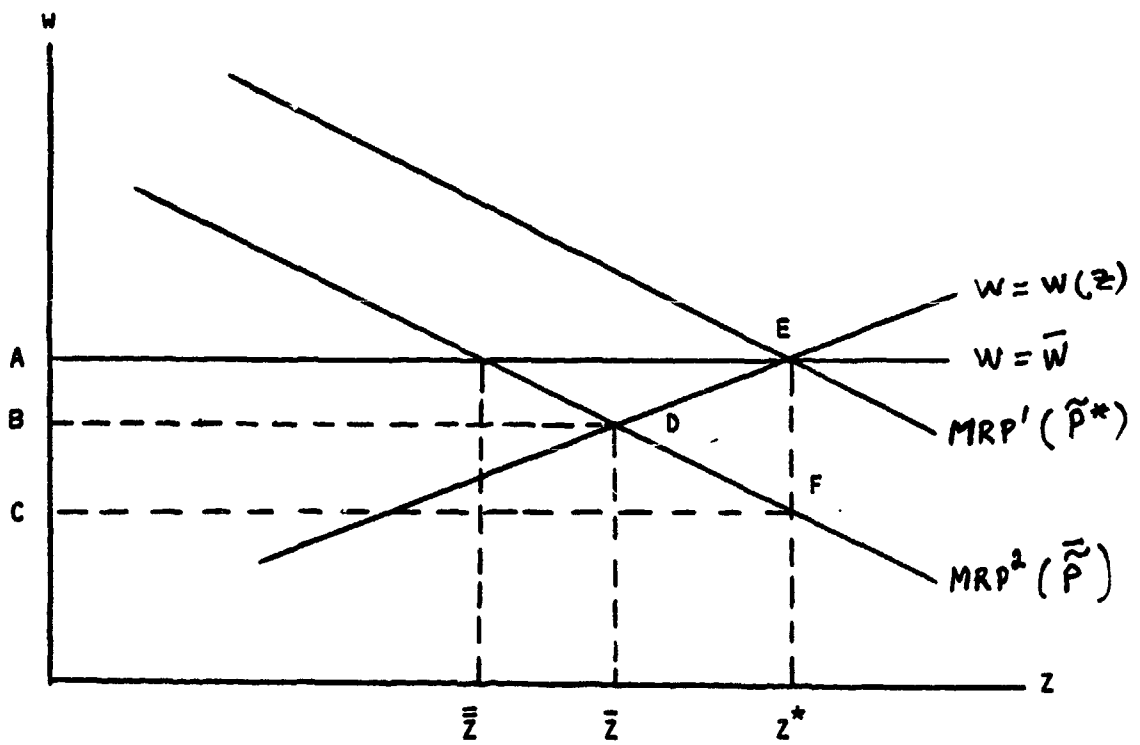
To assess the effects of the VER on the size of the industry (and hence on the size of the representative firm) as measured by the aggregate input  $Z$ , we need to consider whether the marginal revenue product of  $Z$  is increased or decreased by the VER. This can be done entirely in terms of market B. Under free trade the marginal revenue products are equal across markets, while under the binding VER, only market B can accommodate marginal sales. (When the VER is binding, the marginal revenue product available in market A is zero.) Constrained revenue maximization by the representative firm implies that in the new equilibrium:

$$(3) \quad \frac{\overline{dR}_B}{dZ} = \frac{\overline{P}_B}{\overline{G}_B} = \overline{\theta}$$

Since the VER redirects sales from market A to market B, it drives up the costs of producing for market B, since  $G_B > 0$ . Thus, even if demand in market B is perfectly elastic -- i.e.,  $\overline{P}_B = P_B^*$  -- the marginal revenue product of Z is reduced by the VER. If demand is less than perfectly elastic, i.e.  $\overline{P}_B < P_B^*$  this effect is exacerbated by the drop in price. Thus, even if the VER increases the representative firm's total revenue, it always reduces the marginal revenue product of its factor inputs. If the firm is a price-taker in factor markets, falling MRP will cause it to reduce its output and input levels.

Return now to the market for the composite factor Z. Figure 2 illustrates the two cases of interest. The VER causes the marginal revenue product curve to fall, say from  $MRP^1$  to  $MRP^2$ . In the very short-run in which factor inputs cannot be altered at all, the input level remains at  $Z^*$ , but the rents lost amount to area AEFC. This, of course, is the implication derived by considering the allocation model in isolation. In the opposite case, when the footwear industry (in addition to each of its individual firms) faces an infinitely elastic supply of Z, then the new input level is given by  $\overline{Z}$ ; this implies large output losses, but no distortionary resource costs because factors may shift to industries in which they are just as productive as in footwear. Under these circumstances,  $\overline{\theta} = \theta^*$ , and the shift in the marginal revenue product curve must be accommodated by output contraction alone. If, on the other hand, the industry faces an

Figure 2



upward-sloping supply curve for factors, the final input level is  $\bar{Z}$ ; this entails a smaller contraction, but additionally imposes losses of rent -- and hence of welfare -- on factor owners. The losses are given by area AEDB. Now,  $\bar{\theta} < \theta^*$ , and there is an efficiency loss, but it is smaller than that implied in the very short run in which industry factor inputs are fixed.

A more complete exposition of the implications of a VER would relax the representation of the problem in terms of two markets and the two-stage decision by firms. The empirical analysis in section 3 treats the more general case where sales are allocated to one restricted and two unrestricted markets, and we discuss below how to modify the analysis to admit several unrestricted markets. As to the two-stage decision assumption, de Melo and Winters (1989b) show for the general case of a two-output one-input general technology that spillover to unrestricted markets and output contraction will occur unless there is a very strong positive relationship between output destined for one market and the costs of producing for others. Since marginal production costs for each market are likely to show only small interdependencies, it is unlikely that the qualitative predictions of the above analysis would differ in a more general set-up.

Because we have only two markets, we have been able to establish the contractionary effect of a VER by considering the marginal revenue product in each market directly. With more markets, as in the empirical application below, it is convenient to use an alternative approach, derived from Neary and Roberts (1980). These authors show that a constrained equilibrium can be expressed as an unconstrained equilibrium at a different set of prices. These latter prices, which are known as virtual prices, are

simply the set of prices at which, given the overall level of activity, producers would supply voluntarily the actual quantities supplied in the constrained equilibrium. For unconstrained markets, virtual prices are equal to actual prices. Referring back to figure 1, the quantities given by R would be willingly supplied at the set of prices  $(P_A^V, \bar{P}_B)$ .

For any unconstrained equilibrium the marginal revenue accruing from an extra unit of aggregate output  $\tilde{X}$ , optimally allocated, can be written as  $\tilde{P} = \tilde{P}(P_1, \dots, P_n)$ ;  $\partial \tilde{P} / \partial P_i > 0$ , for all  $i$ . For a constrained equilibrium, the Neary-Roberts results allow us to calculate the marginal revenue by evaluating the same function at virtual prices  $(\bar{p})$ . The effect of a binding VER in market  $j$  is to reduce  $P_j^V$  below the actual price, but since the virtual and actual prices of the unconstrained markets are equal, this is sufficient to deduce that  $\bar{\tilde{P}} < \tilde{P}$ . This is the procedure we adopt in section 3 to measure the equivalent of distance EF in figure 2.

### 3. Estimating the Reduction in Factor Demand: Korean Leather Footwear

In this section, we estimate the effect of the USA's Orderly Marketing Agreement (OMA) on non-rubber footwear on the demand for Korean leather footwear producing factors. To keep the results transparent, we continue with our very simple model of footwear exporting. The Korean industry is presumed to produce an aggregate quantity of footwear using a single composite factor of production, and subsequently to allocate this aggregate to one of three markets according to a constant elasticity of transformation (CET) allocation function. This simple function allows us to analyze, albeit indirectly, the efficiency implications of the OMA without access to specific data on the allocation of factor inputs to sales in each market. The crucial parameter in determining the effects of the

OMA is the elasticity of transformation -- i.e. the extent to which production may be shifted between outputs destined for different markets.

Using quarterly data over the period 1975 I to 1986 IV, we estimate the elasticity of transformation between supplies of leather footwear destined for three markets -- the USA, "unconstrained-EC" and the rest of the world. The USA imposed the OMA on Korean exports of non-rubber footwear between the third quarter of 1977 and the second quarter of 1981, inclusive. As explained below, the observations corresponding to the OMA period are not included in the estimation period. The second group -- unconstrained-EC -- comprises France, West Germany, Italy and the Netherlands -- which, according to Hamilton (1989), imposed no quantitative restrictions on Korean footwear exports over our sample period. The rest of the world comprises all other countries, some of which did have import restrictions on footwear, but which may be reasonably treated as unconstrained overall. Although the OMA operated formally between 1977 and 1981, the evidence suggests that the restrictions on Korea ceased to bind by mid-1980 (Aw and Roberts, 1986).

As in the analysis in section 2, the export allocation model presumes that individual Korean exporters are price-takers and that they seek to maximize profits subject to a CET transformation function relating the quantities of each type of footwear export to an overall index of output (input). That is

$$\max_{X_i} \quad \sum_i p_i X_i \quad \text{subject to} \quad \left[ \sum_i a_i X_i^\gamma \right]^{1/\gamma} = \tilde{X}$$

where  $X_i$  is exports to market  $i$ , at price  $p_i$ ,  
 $\tilde{X}$  is the index of aggregate output,  
 and  $\gamma > 1$ .

Writing  $\rho = 1/(\gamma-1)$  for the elasticity of transformation, standard manipulation allows us to express the share of market  $i$  in total exports as (see Hickman and Lau, 1973):

$$(4) \quad s_i = \alpha_i (p_i/p)^\rho \quad ; \quad i = 1, 2, 3$$

where  $s_i$  is the share of  $i$  in the volume of exports,  $s_i = X_i / \sum_j X_j$ ,

$$p \equiv \left[ \sum_j \alpha_j p_j^\rho \right]^{1/\rho} \text{ is a fixed weight price index,}$$

$$\alpha_i = a_i^{-\rho},$$

Both the danger of simultaneity and of errors in variables suggest the need for more robust methods of estimation than are possible for non-linear systems of equations with complex error structures. 5/ We decided, therefore, to linearize the model about a base period (see Hickman and Lau (1973)). Setting prices to unity in the base period (quarter II, 1984), introducing a time-trend with value zero in the base, and adding seasonal factors and dynamics, we estimated

$$(5) \quad y_{it} = \rho a_i^0 (p_{it} - p_t) + \gamma_i t + \sum_1 \delta_{i1} D_1 + \lambda_1 y_{it-1} + \lambda_4 y_{it-4} + u_{it}$$



$y_{it} \equiv s_{it} - a_i^0$  is the deviation of  $i$ 's share from its base value,  
 $a_i^0$ .

$p_t \equiv \sum_j a_j^0 p_{jt}$ , is a based-weighted price index,

$t$  is a time-trend incremented by one per quarter.

$\sum_l \delta_{il} D_l$  are seasonal effects for quarter  $l$ ,  $l = 1, 3, 4$  where the dummy for quarter two has been suppressed because the base period is a second quarter.

$\lambda_1, \lambda_4$  represent dynamic effects on the share of market  $i$ , felt through lags of itself, and

$u_{it}$  are stochastic errors.

The  $y_{it}$  sum to zero over  $i$  in each time period, and so one of equations (5) must be dropped in estimation -- we dropped that for unconstrained Europe. We then estimated the remaining equations by a three-stage procedure allowing the errors,  $u_{it}$ , to be autocorrelated and correlated across markets, imposing the cross-equation parameter constraints ( $\rho$ ,  $\lambda$ , and  $\lambda_4$  appear in both equations), and using instrumental variables to allow for the simultaneity and errors of observation. 6/

Because the OMA disturbed export allocation, the observations 1977 III to 1980 II (when it bound) must be dropped from the estimation period. It also proved unnecessary to include the fourth order lag on  $y_{it}$ . Thus the final equation is as given in table 1. The estimated elasticity of transformation is perhaps a little low, given the anecdotal evidence that exists on the degree of competition and product substitution/homogeneity in world footwear markets; but it is a fairly robust result. Moreover, two other pieces of evidence suggest that Korean exports to different markets

Table 1: THE ALLOCATION FUNCTION FOR KOREAN LEATHER FOOTWEAR EXPORTS

	Leather Footwear	
$\rho$	1.311	(0.756)
$\gamma_R$	-0.0013	(0.0009)
$\gamma_U$	0.0024	(0.0010)
$\delta_{R1}$	0.074	(0.022)
$\delta_{U1}$	-0.076	(0.021)
$\delta_{R3}$	0.060	(0.019)
$\delta_{U3}$	-0.063	(0.018)
$\delta_{R4}$	0.058	(0.019)
$\delta_{U4}$	-0.060	(0.020)
$\lambda_1$	0.401	(0.102)
$\hat{r}$	0.137	
$R^2$ Row	0.80	
USA	0.88	
EC-unconstrained	0.75	
Long-run elasticity of transformation	2.19	

Subscripts R refer to the "rest of the world" and U to the USA.

$\hat{r}$  is first-stage estimate of the autocorrelation parameter.

Standard errors in parentheses.

are imperfect substitutes. First, as we noted above, the unit values of Korean exports to different markets differ by up to 50%, suggesting that there may indeed be genuine product heterogeneity. Second, the estimates in table 1 display dramatically different seasonal patterns -- with the allocation between the US and the rest of the world switching by over ten percentage points with the season.

Table 2 explores the effects of the OMA on Korean exports to the USA more closely. Column 1 reports the difference between the actual share and that predicted by our equation for the constrained period. It is consistently negative suggesting a binding restriction, but it shows signs of weakening over 1980. The second column approximates the proportionate difference between the virtual and actual prices of exports to the USA. Because the actual US share falls short of that predicted by the export allocation model, the virtual price for the USA is below the actual price, by as much as 12% in 1977 III. Thus, the OMA may be seen to have had an effect equivalent to a 5%-12% drop in the price of exports to the USA with no compensating price rises in other markets. This makes it clear that the OMA put pressure on the Korean footwear industry to contract.

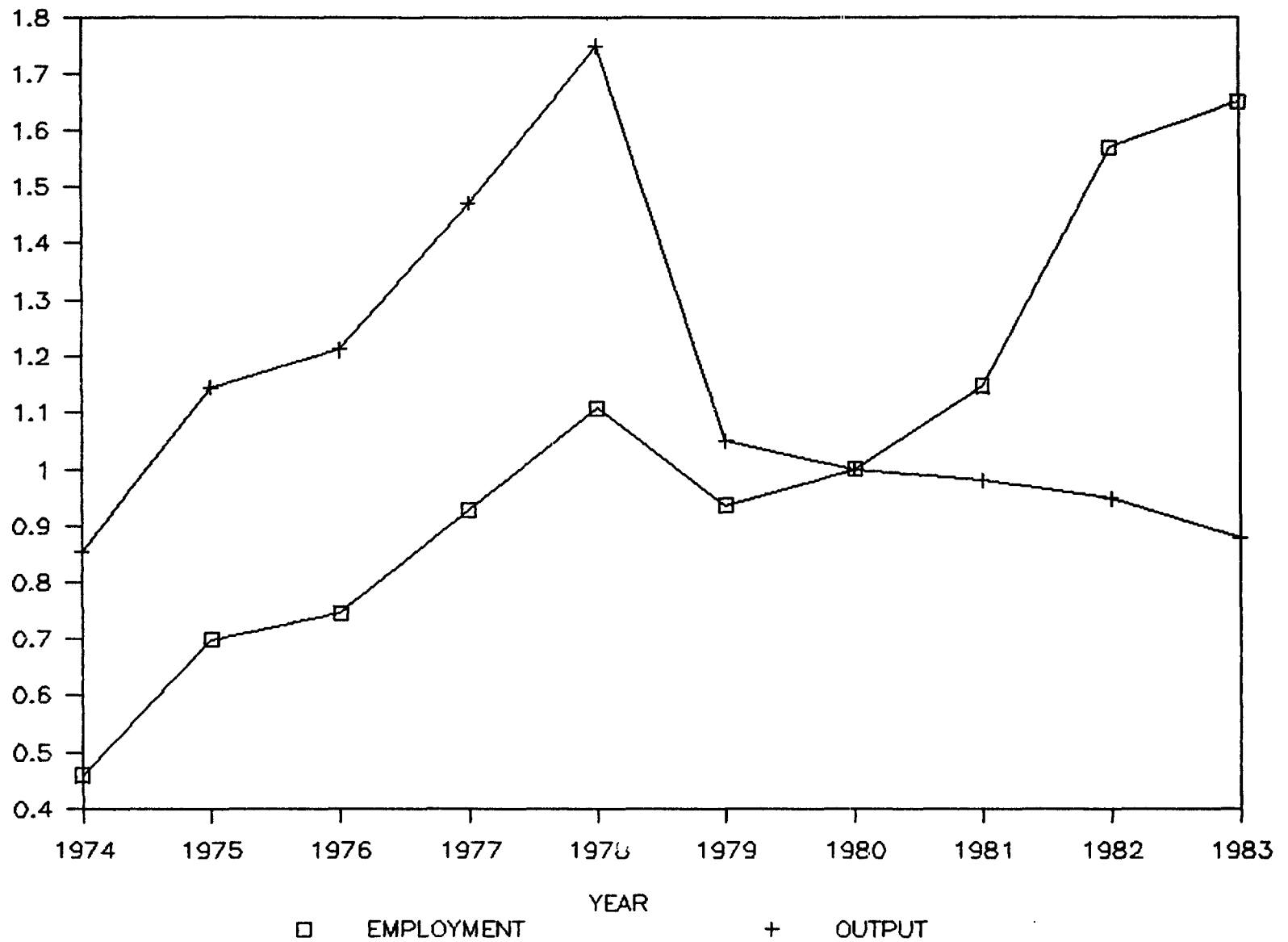
The extent of the contractionary pressure can be calculated as the difference in the aggregate price index evaluated at actual and at virtual prices. This calculation is reported in column (3) of table 2, and is a linear approximation to the change in the marginal return on aggregate activity in the leather footwear sector. It shows that the marginal revenue product of the factors of production in the leather footwear industry declined by as much as 9% because of the OMA, and that the OMA imposed significant pressure for contraction.

**Table 2: THE EFFECTS OF THE OMA ON KOREAN LEATHER  
FOOTWEAR EXPORTS TO THE USA**

Quarter	Residual in share equation	Price change equivalent of OMA	Change in aggregate price index $\frac{\bar{P}}{\bar{P}^*} - 1$
77.3	-0.176	-0.121	-0.095
77.4	-0.024	-0.017	-0.013
78.1	-0.076	-0.050	-0.039
78.2	-0.159	-0.103	-0.081
78.3	-0.098	-0.056	-0.044
78.4	-0.093	-0.051	-0.040
79.1	-0.208	-0.096	-0.076
79.2	-0.188	-0.081	-0.063
79.3	-0.284	-0.110	-0.087
79.4	-0.159	-0.065	-0.051
80.1	-0.052	-0.023	-0.018
80.2	-0.092	-0.040	-0.031

# EMPLOYMENT AND OUTPUT IN FOOTWEAR

FOOTWEAR RELATIVE TO ALL MANUFACTURING



Figure\_3: RATIO OF INDEX NUMBERS 1980=1.

The econometric estimates strongly suggest that the Korean footwear industry would have contracted during the period of the OMA. This prediction is borne out by inspection of time series on output, employment, and wages of the Korean footwear sector (see table A1 in the appendix). The data displayed in figure 3 report footwear output and employment relative to the corresponding series for the entire manufacturing sector. This normalization is necessary to control for the Korean recession of 1980. Even when it is made, the time patterns show clearly that the footwear sector experiences a notable slump during the period when the OMA with the U.S. was in effect. 7/

#### 4. Illustrative Welfare Calculations

The results above confirm that a VER leads to output contraction and has adverse efficiency effects if the factors employed in the industry are not available to it in perfectly elastic supply. However, as discussed in section 2, a VER also results in a sales revenue effect which may either reinforce or counteract the efficiency effects. This section provides rough orders of magnitude of the potential welfare effects of a VER, using the US OMA on Korean exports of leather footwear as a reference.

For the illustrative calculations, we retain our estimate of the elasticity of transformation of section 3 as an estimate of the ease with which exporters may divert sales from restricted to unrestricted markets and complement it with guesstimates of factor supply elasticities and price elasticities of export demand. 8/

The calibrated counterfactual simulations are for the model presented in section 2 with: constant foreign price elasticities of demand; a CET function describing sales allocation; and a constant

elasticity of factor supply. The welfare measure is given by the sum of profits and factor incomes, and the change in welfare is expressed as a share of initial variable factor (Z) income before the VER. The change in factor demand from the restricted industry affects the wages throughout the markets in which they are traded. Because the share of the industry in the market for Z will vary depending on the industry under a VER, we give calculations for cases where the market for the variable factor Z is either 1, 5, or 10 times the initial allocation of Z to the industry under the VER. (The details of the model are given in Appendix B.)

The results of our illustrative calculations for a range of elasticities are given in Table 3. For all calculations, the simulations consist of a 10% reduction in the volume of sales to the restricted market, where the initial share of exports to the restricted market is 42% of total exports (a figure corresponding to the leather footwear case of section 3). Before examining the results in the different columns of the table, where several elasticities are varied simultaneously, we briefly describe the effects of varying elasticities one by one and compare the results with those in column 1 where all elasticities are unity.

In the case of unitary export demand elasticities, there are no sales revenue effects, so it is easy to isolate the effects of varying supply elasticities. The more difficult it is to reallocate the existing volume of production, the higher the efficiency cost of a given VER because the adjustment comes from output contraction rather than from sale reallocation. Likewise, as explained in section 2, the higher the elasticity of factor supply, the lower the efficiency costs of a VER. However, a similar variation (around unity) of the elasticity of factor supply has more of an effect on efficiency than an equal variation of the

**Table 3: ILLUSTRATIVE WELFARE CALCULATIONS**

Elasticities \ Column		(1)	(2)	(3)	(4)	(5)
Price Elasticity of Restricted Demand	( $\epsilon_A$ )	1.0	0.3	0.5	1.0	2.0
Price Elasticity of Unrestricted Demand	( $\epsilon_B$ )	1.0	0.6	1.0	2.0	4.0
Elasticity of Transformation	( $\rho$ )	1.0	0.5	1.5	1.5	3.0
Elasticity of Factor Supply	( $\epsilon_S$ )	1.0	0.5	2.0	2.0	3.0
Simulation Results	$z^c/$					
Output $\underline{a}/$		-5.0	-3.9	-4.3	-4.5	-4.1
Sales Revenue $\underline{a}/$		0.0	11.6	4.6	0.0	-2.1
Factor Wage $\underline{a}/$		-4.0	-7.7	-2.2	-2.3	-1.4
Welfare $\underline{b}/$	1	6.2	19.7	10.2	5.5	2.7
	5	-0.5	6.9	6.5	1.7	0.4
	10	-8.9	-9.1	1.9	-3.0	-2.5

Notes: Notation is given in appendix B.2. Unrestricted equilibrium:  $X_A = 100$ ;  $X_B = 140$ ;  $P_1 = 1.00$ ;  $Z = 100$ .

$\underline{a}/$  Percent change.

$\underline{b}/$  Change in level value.

$\underline{c}/$  Size of market for  $Z$  in relation to initial allocation of  $Z$  in industry subject to VER.



elasticity of transformation. As expected from figure 2, efficiency costs are more sensitive to the elasticity of factor supply than to the elasticity of transformation.

Columns (2) to (5) give estimates of the welfare effects of a VER for low, medium, and high sets of elasticities. The results in column (4) may be viewed as best guess calculations. In this case, there is a net loss if the market for Z is large. On the other hand, if the market for Z is small (relative to the initial allocation of Z to the industry), there is a net gain in spite of the negative efficiency effects because of their smaller weight in the welfare calculation. The same is true for column (2) in the low elasticity case because the larger efficiency costs are offset by larger sales revenue gains with low elasticities. <sup>9/</sup> The simulated decreases in the marginal revenue product of Z (factor wage row in the simulation results section of table 3) are similar in magnitude to the range reported from the econometric estimates in column 3 of table 2. Finally in column (5), with higher demand elasticities, the revenue effect becomes negative implying larger welfare losses. Thus, if demand elasticities are not too low (and supply elasticities are not too high), then a VER is likely to lead to a welfare loss.

## 5. Conclusions

This paper has presented a simple model to analyze the revenue and efficiency effects of a VER at the industry level. Inspired from the evidence that developing countries often have limited success in switching sales towards unrestricted markets, we have separated out revenue effects arising from sales reallocation towards unrestricted markets from efficiency effects arising from output contraction.

The analytical discussion of the effects of a VER was then corroborated with an application to the U.S. OMA agreement with Korean exporters of leather footwear. The econometric estimates indicate both a limited ability to switch sales towards unrestricted markets and a sharp fall in the marginal revenue product of factors employed in the Korean leather footwear industry during the period where the OMA was in effect. Combined with extraneous price elasticity estimates of export demand and factor supply elasticity estimates, illustrative welfare calculations suggest that the OMA may well have resulted in a welfare loss, especially if demand elasticities are relatively elastic and the supply response is not very elastic.

### Footnotes

1/ There is plenty of evidence to suggest that, even at the most disaggregated level for which data exist, export sales to different markets are imperfect substitutes. To take the concrete example of footwear, Korea exports leather outdoor sports shoes to many different markets every year and at prices differing by factors of at least 50 percent (see de Melo and Winters (1989a)). Besides differences in the composition of the export bundle, product differentiation may reflect any of several factors: production to order; the need for marketing structures in importing countries; differences in taste; or a desire for market diversification to reduce uncertainty.

2/ This unrestricted allocation represents the solution of the problem:

$$\text{Max } P_A X_A + P_B X_B \quad \text{s.t. } G(X_A, X_B) = \tilde{X}$$

taking prices as parametric, but where at the final equilibrium, prices and quantities must also satisfy

$$\text{S.T. } X_A = f_A(P_A)$$

$$X_B = f_B(P_B)$$

where  $f_A(\ )$  and  $f_B(\ )$  are demand schedules in markets A and B, and  $G(\ )$  is the index aggregator for footwear exports, which is assumed to be linear homogeneous and quasi-concave.

3/ Increasing marginal costs requires  $G_{AA}, G_{BB} > 0$  and  $G_{AA}G_{BB} - G_{AB}^2 \geq 0$ .

4/ While we do not wish to stress the empirical relevance of this possibility, it has been pointed out in previous theoretical discussions of the effects of VERs in non-competitive markets. See e.g. Harris (1985) and Krishna (1988). It is interesting to speculate that the two-tier quota allocation system used in Korea (and elsewhere) implies that greater sales towards non-restricted markets may have the objective of revenue maximization. For further analysis see Bark and de Melo (1988).

5/ With unrestricted trade, equations (4) could in principle be estimated by system estimation methods. They can also be manipulated to allow estimation under the rationing caused by the OMA, but only at the expense of having to model a very complex error structure during the rationed period (see Winters and Brenton (1988)). Unfortunately, our attempts to apply such manipulations in this case were frustrated by severe numerical difficulties, probably for one of two reasons. First, simultaneity: if Korean footwear are imperfect substitutes for those of other producers, the Korean footwear sector as a whole will face a downward-sloping demand curve, and price will no longer be

exogenous. Second, all trade data, but especially those of developing countries, are subject to recording error.

- 6/ The IV technique was programmed in GAUSS and was based on Aigner, Hsiao, Kapteyn and Wansbeek (1984). It presumes that the instrumental variables (aggregate industrial production, prices and exchange rates in the markets and in Korea) are correlated with the true values of the variables in equation (5) but not their errors of observation. If that is true, our estimates are consistent and asymptotically efficient. Further details on the estimation technique are provided in the appendix.
  
- 7/ The peak of the footwear industry occurred in 1978, one year after the signing of the OMA agreement. Although this peak is later than predicted by our model, it is not out of line with the detailed account of the OMA given by Yoffie (1983). He remarks that Korean producers went to considerable lengths to negotiate the OMA in a fashion that allowed extended periods of adjustment. Thus it is quite conceivable that output and employment remained high into 1978.
  
- 8/ Our estimates of the price elasticity of export demand are consistent with the range of 0.5 to 1.0 reported in Goldstein and Khan (1985).
  
- 9/ The size of the industry in the market for  $Z$  and  $\epsilon_s$  are not independent. For example, for an industry like footwear  $\epsilon_s$  is likely to be in the range of 2 to 4 and the size of the market,  $L$ , for  $Z$  in relation to the initial allocation of  $Z$  in footwear is likely to be 5 or more whereas in textiles, the corresponding pair would be  $\epsilon^s$  in the range of 0.5 to 2.0 and  $L$  in the range of 1 to 5.

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Appendix A:

This appendix gives a more detailed account of the econometric model of export allocation and its estimation than the text. We assume that exporters are price-takers and that they seek to maximize their revenues subject to a CET transformation function relating the quantities of each type of footwear export to an overall index of output (input). Their objective is

$$(A.1) \quad \max_{X_i} \quad \sum_i p_i X_i \quad \text{subject to} \quad \left[ \sum_i a_i X_i^\gamma \right]^{1/\gamma} = \tilde{X}$$

where  $X_i$  is exports to market  $i$ , at price  $p_i$ ,

$\tilde{X}$  is the index of aggregate output,

and  $\gamma > 1$ .

Standard manipulations (cf Armington, 1969) produce supply functions for the individual markets

$$(A.2) \quad X_i = a_i^{-\rho} (p_i/p^*)^\rho \tilde{X}$$

where  $p^*$  is the dual CET price index of  $\tilde{X}$  given by:

$$(A.3) \quad p^* = \left[ \sum_i a_i p_i^{(1+\rho)} \right]^{1/(1+\rho)}$$

and  $\rho = \left( \frac{1}{\gamma-1} \right)$

is the (negative of the) elasticity of transformation between exports for any pair of markets;  $\rho > 0$ .

Further manipulation (cf Hickman and Lau, 1973) transforms (A.2) into the more convenient form:

$$x_i = a_i p_i^\rho \left[ \sum_j a_j p_j^\rho \right]^{-1} X$$

or

$$(A.4) \quad s_i = a_i (p_i/p)^\rho + u_i$$

where  $X \equiv \sum_j X_j$ , is a simple aggregation of exports,

$s_i$  is the share of  $i$  in the volume of exports.

$p \equiv \left[ \sum_j a_j p_j^\rho \right]^{1/\rho}$  is a fixed weight price index,

$$a_i = a_i^{-\rho},$$

and  $u_i$  is a stochastic component added at this stage for estimation purposes.

To facilitate the treatment of simultaneity and errors in variables (A.4) is linearized about a base period. We used 1984 quarter II as base because it lay well outside the period of possible rationing, and yet was relatively central to our sample of unrationed observations. Subsequent tests suggested that the choice of base period affects the results slightly, but not sufficiently to disturb the qualitative conclusions in the text. Setting prices to unity in the base period, introducing a time-trend with value zero in the base, and adding seasonal factors and dynamics, the linearization gives



$$(A.5) \quad y_{it} = \rho a_i(p_{it} - p_t) + \gamma_i t + \sum_l \delta_{il} D_l + \lambda_1 y_{it-1} + \lambda_4 y_{it-4} + u_{it}$$

$y_{it} \equiv s_{it} - a_i^0$  is the deviation of  $i$ 's share from its base value,  $a_i^0$ .

$p_t \equiv \sum_j a_j^0 p_{jt}$ , is a base-weighted price index,

$t$  is a time-trend incremented by one per quarter.

$\sum_l \delta_{il} D_l$  are seasonal effects for quarter  $l$ ,  $l = 1, 3, 4$  where the dummy for quarter two has been suppressed because the base period is a second quarter.

and  $\lambda_1, \lambda_4$  represent dynamic effects on the share of market  $i$ , felt through lags of itself.

Adding up requires the  $\sum_j a_j^0 = 1$  and that  $\sum_j \delta_{jl} = \sum_j \gamma_j = \sum_j u_{jt} = 0$  all  $l$  and  $t$ . The first condition is satisfied automatically and the latter is handled by dropping the equation for unconstrained-EC. Normally, the final estimates are invariant with respect to the equation dropped, but with the methods required by the errors in variables this is no longer so. However, in practice the choice made very little difference.

Adding-up also requires that, unless the errors are characterized by full vector autoregression, the dynamic structure must be common to all commodities. The use of lagged dependent variables may be justified on several grounds -- e.g. partial adjustment of price expectations, as in Hickman and Lau, or habit formation. For systems of sum-constrained equations it represents by far the most convenient approach to dynamic generalization. The choice of lags 1 and 4 to capture the dynamics was made a priori on the basis of previous experience with quarterly data sets.

Equation (A.5) may be stacked over  $i$  and written in matrix form:

$$(A.6) \quad \begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} a_1^0(p_1-p) \quad t \quad 0 \quad D_1 \quad 0 \quad D_3 \quad 0 \quad D_4 \quad 0 \quad Ly_1 \quad L^4 y_1 \\ a_2^0(p_2-p) \quad 0 \quad t \quad 0 \quad D_1 \quad 0 \quad D_3 \quad 0 \quad D_4 \quad Ly_2 \quad L^4 y_2 \end{bmatrix} \begin{bmatrix} \rho \\ \gamma_1 \\ \gamma_2 \\ \delta_{11} \\ \delta_{21} \\ \delta_{13} \\ \delta_{23} \\ \delta_{14} \\ \delta_{24} \\ \lambda_1 \\ \lambda_4 \end{bmatrix} + \begin{bmatrix} u_1 \\ u_2 \end{bmatrix}$$

where  $L$  is the lag operator and all the Roman letters denote  $(n \times 1)$  vectors, where  $n$  is the number of observations.

Ignoring the errors in variables (A.6) may be simply estimated allowing for the autocorrelation and cross equation correlations. Following Parks (1967), we first estimate (A.5) for each commodity separately, and calculate a single first-order autocorrelation coefficient. (The serial correlation adjustment factor must be common to all equations if the system is to add-up). Transforming the data appropriately, we then re-estimate by commodity to calculate  $E(\tilde{u}_{it} \tilde{u}_{jt})$ , where the  $\tilde{u}_i$  are the errors from the transformed equations. Finally, using these variances and covariances, we transform the data again to estimate (A.6) by GLS.

To allow for the simultaneity and the errors in variables we use instrumental variable estimation. Instruments were drawn from both the importing countries (industrial production, the wholesale price index for

manufactures, and the exchange rate vis-à-vis the dollar) in order to reflect demand factors, and from Korea (the unit value of manufactured exports, the index of industrial production and the dollar exchange rate) to reflect broad supply-side phenomena. Whenever  $L_y$  and  $L^4y$  are included in the equation the instrumental variables are also included in the correspondingly lagged form. Finally, the genuinely exogenous variables in (A.6) -- i.e.  $D_i$  and  $t$  -- are also included in the set of instruments.

The estimation method is based on Aigner, Hsiao, Kapteyn and Wansbeek (1984). We assume that there exists a true relationship equivalent to equation (A.6), but without errors in variables, and which may be written in obvious notation as:

$$(A.7) \quad y = \Xi \beta + u ;$$

that the relationship between the true ( $\Xi$ ) and the observed ( $X$ ) independent data is

$$(A.8) \quad X = \Xi + V ;$$

and that there exists a set of relationships between the  $k$  true independent variables and the  $l$  indicator (instrumental) variables ( $Z$ ).

$$(A.9) \quad Z = \Xi \Gamma' + \Delta .$$

The error terms  $V$  and  $\Delta$  are assumed to be independently normally distributed with zero means and also to be independent of  $\Xi$ . The covariances of the rows of  $V$  and  $\Delta$  ( $v_t$  and  $\delta_t$ ) are given by  $\Omega$  and  $\theta$  respectively and the

variance of  $u$  by  $\sigma^2$ . The true independent variables are assumed to have an expected scaled cross-product matrix,  $K$ ,  $K = E m^{-1} \bar{X}' \bar{X}$ , where  $m = 2n$  is the number of rows in the matrices  $y, X, Z, \bar{X}, V$  and  $\Delta$ . Following Aigner et al. we can write the various covariance matrices  $\Sigma_{IJ} = E m^{-1} I' J$ ,  $I, J = X, y, Z$  as

$$(A.10a) \quad \Sigma_{yy} = \sigma^2 + \beta' K \beta$$

$$(A.10b) \quad \Sigma_{xy} = K \beta$$

$$(A.10c) \quad \Sigma_{zy} = \Gamma K \beta$$

$$(A.10d) \quad \Sigma_{zz} = K + \Omega$$

$$(A.10e) \quad \Sigma_{zx} = \Gamma K$$

$$(A.10f) \quad \Sigma_{zz} = \Gamma K \Gamma' + \theta$$

Equations (A.10c) and (A.10e) yield

$$\Sigma_{zy} = \Sigma_{zx} \beta$$

from which, multiplying both sides by  $\Sigma_{zx}' \Sigma_{zz}^{-1}$ , and substituting sample values  $S_{IJ}$  for population values  $\Sigma_{IJ}$  we obtain

$$\begin{aligned} (A.11) \quad \hat{\beta} &= (S_{zx}' S_{zz}^{-1} S_{zx})^{-1} S_{zx}' S_{zz}^{-1} S_{zy} \\ &= (X'Z (Z'Z)^{-1} Z'X)^{-1} X'Z (Z'Z)^{-1} Z'y. \end{aligned}$$

$\hat{\beta}$  is multivariately normally distributed with asymptotic variance

$$(A.12) \quad \text{var}(\hat{\beta}) = (\sigma^2 + \beta' \Omega \beta) (S'_{2X} S_{22}^{-1} S_{2X})^{-1}$$

which is the minimum variance bound that can be derived from (A.12) by linear methods. We approximate (A.12) below by substituting  $\hat{\beta}$  for  $\beta$  and using (A.10) to express the first bracket in terms of observables.

System (A.10) presumes that the errors are i.i.d., but in our case we need to allow for the presence of autocorrelation and the fact that  $E(u_{1t} u_{2t}) \neq 0$  where  $u_1$  and  $u_2$  are sub-vectors of  $u$  referring to the first and second equations. In fact, however, these modifications make virtually no difference to the estimator. Taking the latter first, partitioning all variables in (A.7) to (A.9) conformably with  $u_1$  and  $u_2$ , versions of (A.10) may be derived for all combinations of  $y_i$ ,  $X_i$  and  $Z_i$ ,  $i = 1, 2$ . If the only change in assumption is that  $E(u_i u_j) = \sigma_{ij}$ ,  $i \neq j$ , only (A.10a) is changed; it becomes

$$(A.10a') \quad \Sigma_{y_i y_j} = \sigma_{ij}^2 + \beta' K \beta$$

In all other equations the partitioned covariances are the same as the unpartitioned ones in (A.10). This means that the same instrumental estimation method may be applied to a set of first stage estimators to derive the  $\hat{\sigma}_{ij}$ , which are then used to transform all the observable data into the form assumed in the main stage just described. Provided that the estimates of  $\sigma_{ij}$  are consistent, the asymptotic properties of the final estimates are unchanged. A similar approach is taken to the autocorrelation.

The variance estimate (A.12) may be used to conduct statistical inference on the coefficients. The validity of a set of linear constraints  $Q\beta = r$  may be explored by means of the test statistic

$$(Q\hat{\beta} - r)' [Q \text{Var}(\hat{\beta}) Q']^{-1} (Q\hat{\beta} - r)$$

which is distributed  $\chi^2_q$  under the null hypothesis, see Amemiya (1985).

The data were collected and prepared by Taeho Bark and Paul Brenton, to whom we are most grateful. They are fully described in the Appendix of de Melo and Winters (1989a). In terms of the final classifications used in table 2 of that source, leather footwear comprises headings 6402.1000-6402.4900.

Table A1: THE KOREAN FOOTWEAR SECTOR, 1974-83

	Footwear			Footwear As percent of total manufacturing		
	Employment <u>a/</u>	Output <u>b/</u>	Wages <u>c/</u>	Employment <u>a/</u>	Output <u>d/</u>	Wages
1974	6600	33	303	0.518	85.3	85.3
1975	11000	53	364	0.788	114.5	77.9
1976	14200	74	493	0.84	121.3	82.6
1977	19800	108	657	1.046	147.1	85.1
1978	26000	159	846	1.249	174.9	79.3
1979	22000	107	1136	1.055	105	81.1
1980	22700	100	1366	1.127	100	79.2
1981	26000	111	1538	1.293	97.9	74.8
1982	36500	113	1809	1.77	94.6	78.4
1983	40500	122	2025	1.86	87.8	80.2

a/ In thousands.b/ Index 1980 = 100.c/ (thousands of won)/yeard/ Ratio of index numbers (1980 = 100).

Appendix B 1/General Model and Welfare CalculationsB1 General Model

Consider the general case of firms in perfect competition in which the allocation and input decisions are made jointly. In this case weak separability is not imposed so that allocation and production decisions must be considered together. Technology is represented by a one-input, two-output production function. Let variable factor requirements,  $Z$ , destined to the restricted ( $X_A$ ) and unrestricted ( $X_B$ ) markets be given by:

$$(B1) \quad Z = G(X_A, X_B)$$

where  $Z$  is the quantity used of the composite factor

$$G_i \text{ is } \partial Z / \partial X_i > 0$$

$G$  is homothetic and homogenous of degree  $r < 1$

Under the assumption of profit maximization, de Melo and Winters (1989b) show that the imposition of a VER on sales to A ( $\bar{X}_A < X_A^*$ ), leads to the following expressions for output (B2) and for national welfare (B3).

$$(B2) \quad \frac{1}{G_A} \frac{dZ}{d\bar{X}_A} = \frac{\frac{G_B}{X_B \epsilon_B} - G_{BB} + \frac{G_B}{G_A} G_{BA}}{\left[ \frac{G_B}{X_B \epsilon_B} - G_{BB} - \frac{G_B^2}{Z \epsilon_Z} \right]} = H$$

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1/ This appendix draws on de Melo and Winters (1989b).



$$(B3) \quad \frac{dU}{d\bar{X}_A} = \left[ \left[ \frac{1}{\epsilon_A} - \frac{1}{\epsilon_B} \right] + \left[ \frac{1}{\epsilon_B} - \frac{1}{\epsilon_N} \right] H \right] G_A$$

where  $\epsilon_A$ ,  $\epsilon_B$ ,  $\epsilon_N < 0$  are respectively the elasticities of demand for A and B and the elasticity of demand for the variable factor Z with respect to the wage in other sectors using Z, and  $\epsilon_Z > 0$  is the elasticity of supply of Z. From (B2), it is clear that a VER in A will most likely lead the industry to contract if one assumes increasing marginal costs, i.e.  $G_{ii} > 0$ , and if one recognizes the constraints imposed by the second-order conditions for profit maximization. Only very strong (and implausible) interactions between A and B leading to a large positive value for  $G_{AB}$  would lead the industry to expand. Hence, a VER is likely to lead the industry to contract.

From (B3), the change in national welfare (where national welfare is the sum of industry profits and payments to the factors of production) is determined by an allocation component which measures whether switching sales from A to B raises revenue, and a size component which measures whether switching factors across sectors is beneficial.

## B2. Welfare Calculations

The welfare calculations in section 4 comes from a numerical application of the model presented in section 2 with: constant elasticity of demand curves (equations B4 and B5); a CET function to allocate sales between the restricted and unrestricted markets A and B (equation B6); a constant elasticity of supply function for the factor, Z (equation B11). An unrestricted equilibrium is described by the following set of equations:

$$(B4) \quad X_A = \bar{A}_A P_A^{-\epsilon_A} \quad \epsilon_A > 0$$

$$(B5) \quad X_B = \bar{A}_B P_B^{-\epsilon_B} \quad \epsilon_B > 0$$

$$(B6) \quad \tilde{X} = \bar{A}_C (a_A X_A^\gamma + a_B X_B^\gamma)^{1/\gamma} \quad \rho = 1/\gamma - 1 ; \gamma > 0$$

$$(B7) \quad P_A = \theta^* \bar{A}_C^{(\rho+1)/\rho} a_A (X_A/\tilde{X})^{1/\rho}$$

$$(B8) \quad P_B = \theta^* \bar{A}_C^{(\rho+1)/\rho} a_B (X_B/\tilde{X})^{1/\rho}$$

$$(B9) \quad \tilde{X} = X^S$$

$$(B10) \quad X^S = \bar{A}_S Z$$

$$(B11) \quad Z = \bar{A}_2 P_2^{\epsilon_2} \quad \epsilon_2 > 0$$

$$(B12) \quad P_Z = \bar{A}_S \theta^*$$

where  $\bar{A}_i$ ,  $i \in A, B, C, Z, S$  are normalizing constants determined by calibration, i.e. constants calculated so that the set of equations describing the model is satisfied for initially set of prices and quantities. In the free trade equilibrium, industry profits,  $\pi$ , are zero as sales revenue equal payments to  $Z$ ,  $P_Z Z$ .

With the VER,  $X_A$  is fixed at  $\bar{X}_A < X_A^*$  and the first order condition for the allocation to the restricted market (B8) is dropped. As explained in section 2, as a result of the VER,  $\bar{\theta} < \theta^*$  (unless  $\epsilon_2 = \infty$ ).

The welfare measure is:

$$(B13) \quad \Delta W = W_1 - W^* = (\Delta \pi + \Delta P_Z L) / P_Z Z$$

where  $L$  is a scalar indicating the size of the industry in the market for 2.

The calculations in section 4 are obtained from solving the model represented by equations (B4)-(B12) for an unrestricted equilibrium and for a restricted equilibrium with  $\bar{X}_A = 0.9 X_A^*$ . Where elasticities are varied, the  $\bar{A}_i$  parameters are recalibrated so as to start from the same initial unrestricted values for prices and quantities.

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